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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/GB90/00516 (22) International Filing Date: 5 April 1990 (05.04.90) (30) Priority data: 8907820.8 7 April 1989 (07.04.89) GB (71)(72) Applicant and Inventor: AUBUSSON, Russell, C. [GB/GB]; 40 Townshend Avenue, Irby, Wirral, Merseyside L61 2XW (GB). (74) Agent: WELLS, Keith, R.; Potts, Kerr & Co., 15 Hamilton Square, Birkenhead, Merseyside L41 6BR (GB). (81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.		Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: LASER-WRITTEN MOVING IMAGE DISPLAY APPARATUS <div style="text-align: center;"> </div> (57) Abstract <p>A laser-written moving image display apparatus comprising a source capable of producing an ultra-violet laser beam, a screen comprising an aligned arrangement of first, second and third types of phosphors, said first type of phosphor fluorescing so as to emit visible red light when impinged upon directly by said laser beam, said second type of phosphor fluorescing so as to emit visible green light when impinged upon directly by said laser beam and said third type of phosphor fluorescing so as to emit visible blue light when impinged on directly by said laser beam, deflector means for deflecting said laser beam so as to cause said beam to scan said screen and control means for controlling the intensity of the laser beam and for synchronising signals transmitted to said laser and to said deflection means whereby said laser simultaneously addresses said phosphor and provides the energy for illumination.</p>		

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TITLE OF THE INVENTIONLaser-Written Moving Image Display ApparatusFIELD OF THE INVENTION

The present invention relates to an apparatus for displaying monochromatic or coloured moving images. More particularly, the present invention relates to an apparatus for displaying images in which a laser is used to illuminate phosphorised panels.

BACKGROUND OF THE INVENTION AND PRIOR ART DISCUSSION

Apparatuses are known for displaying moving images. Thus, it is known to form images by projecting light through a photographic film onto a reflective screen. Alternatively, back-projection onto a translucent screen may be employed. In conventional television sets, the images are formed by the controlled illumination of the phosphorised inner surface of a cathode ray tube. None of these techniques are well-suited to display moving pictures on large screens outdoors.

To overcome this disadvantage, a known apparatus comprises a plurality of large panels, each of which has a large number of individually illuminable light sources. The light sources provide controlled intensity in each of the three primary colours and are suitably arranged to give an acceptable definition of the image at a pre-determined distance of observation. Such a known apparatus necessitates the use of a large number of separately addressable light sources with inherent high manufacturing and maintenance costs.

In British Patent Specification No. 2118803, there is described and claimed an image display device.

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Such device comprises a light source capable of producing and deflecting a beam. Such beam may be of visible light but is preferably ultra-violet radiation. The device further includes an image intensifier which receives, intensifies and displays the output of the source and which has a screen with red, green and blue light emitter areas arranged side-by-side thereon. Control means are provided for applying, to the source signal, components representing the appropriate colours as the beam is directed to the respective light emitter areas.

This prior document specifically states that the function of the addressing of the light sources and providing energy for illumination are separated. A laser is used for supplying the signal for addressing and controlling the main source of illumination which latter is the image intensifier. The use of an image intensifier has two major inherent disadvantages firstly, such intensifiers are expensive to produce and are vulnerable to exposure to the elements. Secondly, there is a need to protect the image intensifier from spurious triggering by ambient light. To overcome this latter problem, the ultra-violet laser beam is radio-frequency modulated.

OBJECTS OF THE INVENTION

The present invention seeks to provide an image display apparatus in which the disadvantages of known apparatuses are overcome or, at least, minimized. More specifically, the present invention seeks to provide an apparatus in which the need for utilising an image intensifier is obviated. Furthermore, the present invention seeks to provide an apparatus in which visible light is created by fluorescence.

SUMMARY OF THE INVENTION

According to the present invention, there is provided a laser-written moving image display apparatus

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comprising a source capable of producing an ultra-violet laser beam, a screen comprising an aligned arrangement of first, second and third types of phosphors, said first type of phosphor fluorescing so as to emit visible red light when impinged upon directly by said laser beam, said second type of phosphor fluorescing so as to emit visible green light when impinged upon directly by said laser beam and said third type of phosphor fluorescing so as to emit visible blue light when impinged on directly by said laser beam, deflector means for deflecting said laser beam so as to cause said beam to scan said screen and control means for controlling the intensity of the laser beam and for synchronising signals transmitted to said laser and to said deflection means whereby said laser simultaneously addresses said phosphors and provides the energy for illumination.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be further described, by way of example, with reference to the accompanying drawings, in which: -

Fig. 1 is a schematic illustration of an image-forming apparatus in accordance with the present invention; and

Fig. 2 shows a block diagram of the apparatus shown in Fig. 1 and of a control mechanism for controlling the apparatus.

DESCRIPTION OF PREFERRED EMBODIMENTS

In Fig. 1, there is shown an image-forming apparatus in accordance with the present invention. Such apparatus comprises a laser 11 which produces a beam 12 f

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ultra-violet radiation. The beam then passes through a distortion compensation device 13 which, in this embodiment, is in the form of an acousto-optic deflector. Such deflector compensates for beam distortion produced by beam reflector devices to be described in greater detail hereinafter.

After passing through the distortion compensation device 13, the beam impinges upon a first reflector device 14 which is in the form of a mirror having a plurality of facets. In the embodiment shown, the mirror is rotatably mounted about a horizontal axis; the drive means for producing such rotation being in the form of an electric motor 15. The reflected beam then impinges upon a second reflector device 16 which, again, is in the form of a mirror having a plurality of facets. The mirror 16 is mounted for rotation about a vertical axis and is driven by an electric motor 17. Reflection of the beam by the mirror 16 directs the beam onto a display screen 18.

The screen 18 is provided with suitably disposed arrays of three different phosphors which, when illuminated by the ultra-violet laser beam, emit visible red, visible green and visible blue light. In the embodiment shown, the phosphors are arranged in horizontal lines with the minimum practicable spacing between the lines with the sequence of lines being red (R), green (G), blue (B), red, green, blue and so on from top to bottom of the screen. Six hundred and twenty-five lines of each of three phosphors are provided. For the sake of clarity, only a small number of these lines are shown in Fig. 1.

The method of operation of the apparatus will now be described with reference to the block diagram shown in Fig. 2. Initially, the data relating to a single frame

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is extracted from a frame store 19 and is processed in a signal generator 20. This latter produces a voltage-modulated signal 22 which controls the intensity of the ultra-violet radiation emitted by the laser 11. Moreover, the signal generator also produces synchronising signals 23 which are fed to a controller 21. This controller 21 transmits signals to the motors 15 and 17 to rotate the mirrors 14 and 16. The rotation of the mirrors causes the laser beam, which has already been deflected by the acousto-optic deflector 13 to compensate for distortion produced by the mirrors 14 and 16 to impinge on the desired area of the screen such that a true image of the original single picture frame is displayed.

As the mirror 16 rotates in the direction of the arrow shown in Fig. 1, the laser beam sweeps a path from left to right across the screen. In the position shown in Fig. 1, the laser is sweeping across a line of phosphors which fluoresce and emit blue light when impinged upon by the laser. The intensity and brightness of the blue coloration is, of course, dependent upon the intensity and brightness of the coloration in the original frame. When the beam has reached the end of one line of phosphors, a new line scan is commenced. At such time, the next facet of the mirror 16 is directing the laser beam onto the left-hand end of the new line. The appropriate line intensity modulation signal is fed to the laser beam so that the power of the beam and the fluorescent light emitted by the phosphor, which will now be red, vary across the line in accordance with the original frame. In the next line, the fluorescent light emitted by the phosphor is green. The line scanning is continued until all 1875 lines (625 of each colour) have been scanned. The horizontally mounted mirror 14 continues to rotate and, after a short period of time of the order of five milliseconds, the adjacent facet of the mirror is in the

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correct position to cause the beam to scan the top line in accordance with the next frame.

Various components of the apparatus will now be described in greater detail. Thus, the mirror surfaces must be highly reflective to ultra-violet radiation at the wavelength emitted by the laser. This is necessary to maximise the efficiency of the use of the output of the laser and also to avoid unwanted heating of the mirror. Such heating will, of course, occur if an appreciable portion of the power of the beam passes through the reflective layer and is absorbed by the mirror. Thus, it has been found that if aluminium is vacuum-deposited, in the form of an opaque layer, on polished glass, the reflectivity is of the order of 90% in the range of 300 to 400 nm and is still of the order of 85% at 200 nm. At 400 nm, silver has a reflectivity of 93% but this figure is appreciably lower at shorter wavelengths.

The bodies of the mirrors may be made of glass or any other material which is sufficiently rigid to withstand high rotational speeds, can be worked to provide precise surface geometry and to which a suitable reflective layer can be adhered. Although aluminium is difficult to polish, it can provide very precise surface geometry and is therefore suitable for use. To prevent tarnishing and to optimise reflectivity, the aluminium is surface-coated with a dielectric of suitable thickness and refractive index for the laser wavelength being used.

As stated hereinbefore, each mirror has a plurality of facets. The maximum and optimum number of facets depend on a number of factors, such as the spacing of the screen from the mirror and the dimensions of the screen. By way of example only, it is pointed out that a 5° deflection between the extreme left-and right-hand

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edges of the screen would permit a maximum of 144 facets to be employed on the mirror 16. Whilst it is advantageous to use as many facets as possible because this reduces the required rate of rotation of the mirror, it is, in practice, not desirable so to do. By reducing the number of facets, it is not necessary to use the extreme edges of each facet and allowances are made for minor inaccuracies in the synchronisation of the mirror position with the laser power modulation. Thus, if it is desired to illuminate 625 lines of each of the three different phosphors 25 times per second, a mirror having 100 facets would need to be rotated at a speed of 468.75 revolutions per second. It should, perhaps, be pointed out that only eight facets are shown on the mirror 16 in Fig. 1 purely for the sake of clarity. The mirror 14, which also has only eight facets shown for the sake of clarity, is rotated at a much lower speed. Thus, only twenty-five facets need to be presented each second to construct the twenty-five individual three-colour frames to be displayed each second. The presentation of twenty-five or more frames per second is highly desirable to prevent flicker.

Depending upon the geometry and position of the mirrors, crossed axis mirrors tend to produce distortion in the image produced. In order to compensate for such distortion, and thereby to ensure that the laser beam accurately scans along each line of phosphors, an acousto-optic deflector 13 is provided. The material used as the deflector depends upon the nature of the laser and the desired efficiency of the deflector. At wavelengths of approximately 360 nm and above, deflectors based on Tellurium oxide crystals are highly efficient. At shorter wavelengths, quartz crystals may be employed but these are less efficient.

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If the distortion produced is calculated to be insufficient to cause the laser to become out of alignment with the phosphors, the deflector 13 could be omitted and the position of the mirrors 14 and 16 in the beam path reversed. Similarly, it would be theoretically possible to eliminate distortion without the use of the deflector 13 simply by adjusting the rotational speeds of the mirrors. However, it is believed that this would be difficult to achieve in practice.

It is also theoretically possible to dispense with the mirror 14 in two different ways. Firstly, the mirror 16 could be mounted, together with its motor 17, in gimbal bearings which permit the mirror to be deflected about a horizontal axis which is orthogonal to the line of projection of the beam from the mirror to the screen. However, this would entail the use of complex and heavy-duty bearings which could, in extreme circumstances, cause distortion of the mirror itself. Secondly, the mirror 16 could be provided with angled facets, that is to say, facets cut at small incremental angles to the axis of the mirror. Whilst such an arrangement will produce, without significant distortion, the incremental deflections necessary to produce consecutive lines of each frame, the practical limit for the number of facets is of the order of one hundred. It would therefore appear necessary for the beam to be split in order for, say, ten complete revolutions of the mirror to produce one complete frame.

It has surprisingly been found that the phosphors used in conventional colour television sets are suitable for use in the present invention. Thus, the phosphor used to produce red light is Yttrium Oxysulphide plus Europium and Terbium ($Y_2O_2S:Eu:Tb$), that to produce blue light is Zinc Sulphide plus Silver ($ZnS:Ag$) and that to produce green light is Zinc Cadmium Sulphide plus

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Copper [(Zn, Cd)S: Cu]. Of these, the "red" phosphor is a "Characteristic Phosphor", that is to say, the energy level changes are those of the activator whilst the "green" and "blue" phosphors are "Non-Characteristic Phosphors" which means that the energy level changes arise from the impurity-induced lattice modification. It is surprising that the phosphors work in the present invention because, in a television set, they are bombarded with electrons whilst, in the present invention, they are scanned by an ultra-violet laser beam. It could not be predicted that the different types of irradiation will necessarily produce the same effect. Compensation can be made for any colour imbalance by appropriate modulation of the laser beam so that the beam intensity thereof is reduced when the appropriate lines of phosphors are being scanned.

The laser 11 may be of any suitable type which produces a narrow beam of ultra-violet radiation. The presently preferred laser is an Argon Ion Laser which is of the continuous wave type. A known laser of this type is a 7-watt continuous wave laser. However, depending upon the particular circumstances, other lasers such as Excimer lasers could possibly be used. Furthermore, techniques such as frequency multiplication could be employed.

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CLAIMS

1. A laser-written moving image display apparatus comprising a source capable of producing an ultra-violet laser beam, a screen comprising an aligned arrangement of first, second and third types of phosphors, said first type of phosphor fluorescing so as to emit visible red light when impinged upon directly by said laser beam, said second type of phosphor fluorescing so as to emit visible green light when impinged upon directly by said laser beam and said third type of phosphor fluorescing so as to emit visible blue light when impinged on directly by said laser beam, deflector means for deflecting said laser beam so as to cause said beam to scan said screen and control means for controlling the intensity of the laser beam and for synchronising signals transmitted to said laser and to said deflection means whereby said laser simultaneously addresses said phosphors and provides the energy for illumination.

2. An apparatus as claimed in claim 1 wherein said source is a continuous wave ultra-violet laser.

3. An apparatus as claimed in claim 2 wherein said source is an argon ion laser.

4. An apparatus as claimed in claim 1 wherein said source is a visible-light laser subjected to frequency multiplication to produce an ultra-violet laser beam.

5. An apparatus as claimed in any one of claims 1 to 4 wherein said first, second and third types of phosphors are arranged in horizontal rows or vertical columns, each said row or column being either continuous or discontinuous.

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6. An apparatus as claimed in any preceding claim wherein said first type of phosphors are all yttrium oxysulphide-europium-terbium ($\text{Y}_2\text{O}_2\text{S:Eu:Tb}$) phosphors.
7. An apparatus as claimed in any preceding claim wherein said second type of phosphors are all zinc cadmium sulphide-copper $[(\text{Zn Cd})\text{S:Cu}]$ phosphors.
8. An apparatus as claimed in any preceding claim wherein said third type of phosphors are all zinc sulphide-silver (ZnS:Ag) phosphors.
9. An apparatus as claimed in any preceding claim wherein the deflector means comprise at least one mirror having a plurality of facets on its reflective surface and lying in the beam path between said source and said screen, each said mirror being mounted for rotation and drive means for rotating each said mirror.
10. An apparatus as claimed in claim 9 wherein a single mirror is provided, said mirror having facets cut at small incremental angles to the axis of the mirror.
11. An apparatus as claimed in claim 9 wherein a single mirror is provided, said mirror having a plurality of facets cut parallel to the axis of the mirror, the mirror being mounted in gimbal bearings.
12. An apparatus as claimed in claim 9 wherein two mirrors, each having a plurality of facets cut parallel to the axis of the mirror, are employed, the axes of the two mirrors extending at right angles to one another.
13. An apparatus as claimed in any one of claims 9 to 12 additionally comprising an acoustic-optic deflector

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disposed in the beam path, the d flector being based on a tellurium oxide crystal.

14. An apparatus as claimed in any one of claims 9 to 13 wherein said control means comprises a signal generator receiving data from a frame store, said generator producing a voltage-modulated signal controlling the intensity of the laser beam and synchronising signals fed to a control device to cause said device to act on said drive means for each said mirror.

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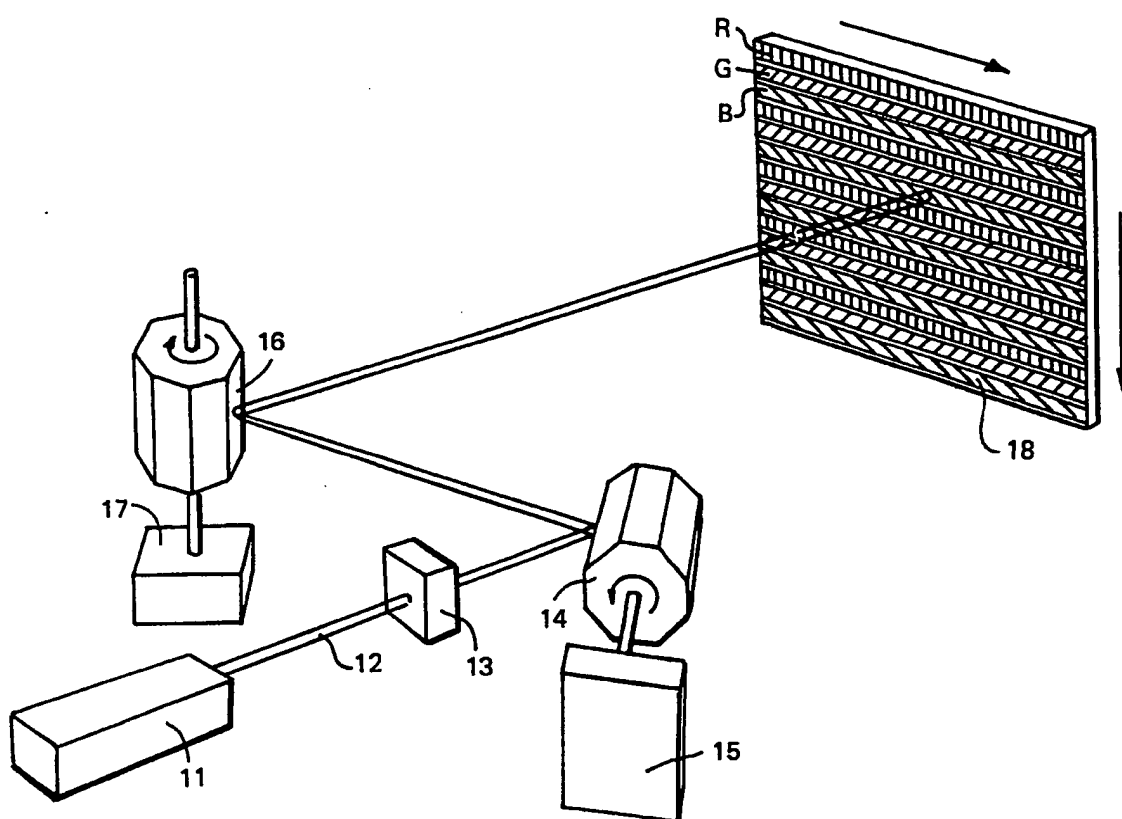


FIG.1

SUBSTITUTE SHEET

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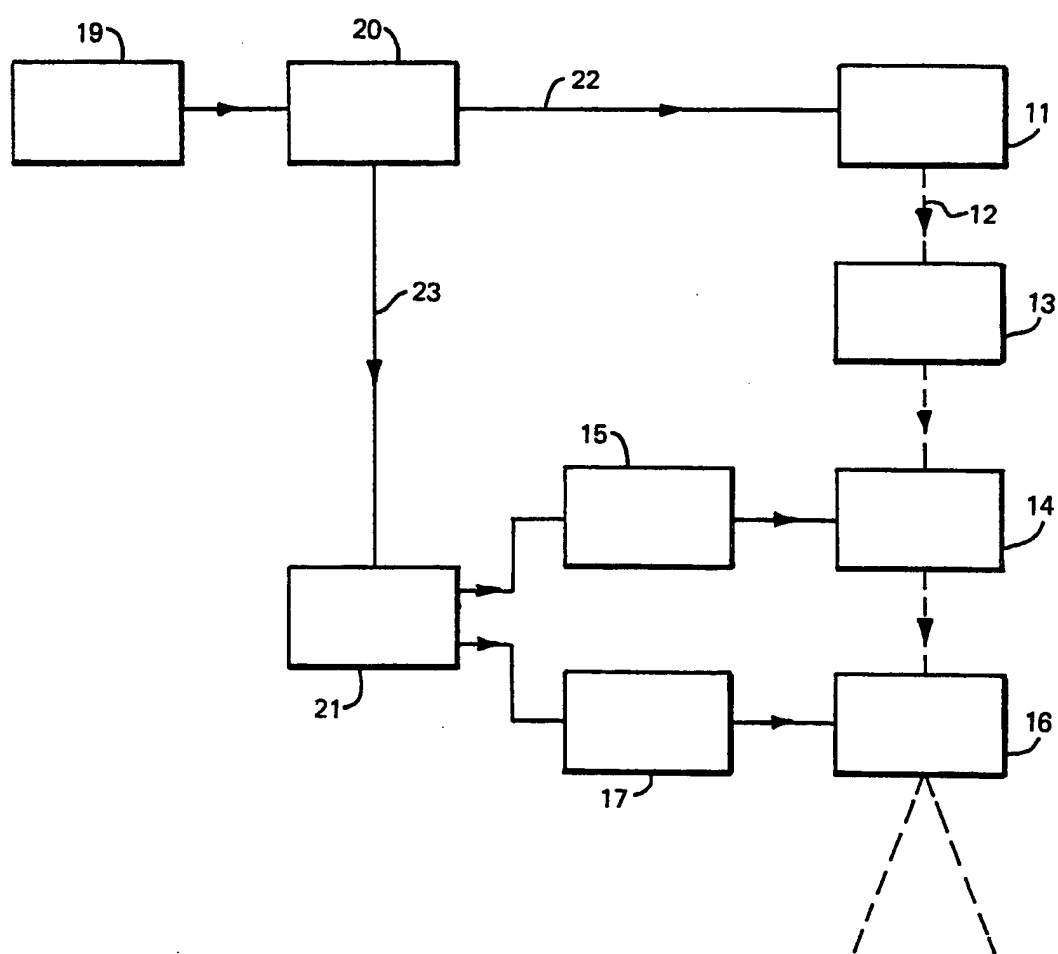



FIG.2

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/00516

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁵ : G 09 G 3/02		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁵	G 09 G	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	GB, A, 2118803 (BRITISH BROADCASTING CORP.) 2 November 1983 see figure 1; page 1, lines 20-61 cited in the application --	1,2,5
Y	EDN, vol. 15, no. 2, 15 January 1970 (Newton, Massachusetts, US) "Design News", pages 22-23, see page 22, second article --	1
A	I.E.E.E. Spectrum, vol. 5, no. 12, December 1968 (New York, US) C.E. Baker: "Laser display technology", pages 39-50; figures 1,2,8,9; page 40, lines 2-5; page 42, right-hand column, lines 9-12 --	1,3,9,10,12
A	Patent Abstracts of Japan, vol. 10, no. 269 (C-372), 12 September 1986 & JP, A, 61091281 (HITACHI LTD) 9 May 1986 --	6,8 ./.
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>¹⁴ Special categories of cited documents: ¹⁵</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
16th July 1990	28. 08. 90	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	 H. Bellstedt	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	<p>Patent Abstracts of Japan, vol. 7, no. 17, (E-154), 22 January 1983 & JP, A, 57174832 (TOKYO SHIBAURA DENKI K.K.) 27 October 1982</p> <p>-----</p>	7

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 9000516

SA 35972

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 20/08/90
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 2118803	02-11-83	None	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82